NSF
Particle and Nuclear Astrophysics (PNA) Program

Astroparticle Physics Projects
(MPS/PHY Division Activities)

Jim Whitmore, Program Director for the PNA program

- Process, Advice, Agency Discussions
- Past funding, statistics
  - Dark Matter
  - UHE Cosmic Rays and Gamma Rays
  - UHE Neutrinos
  - Neutrino Properties
  - Solar Neutrinos
  - Origin of the elements
  - Structure of the Universe
  - CMB Polarization
  - Dark Energy
  - R&D
  - E&O, Broader Impacts for all
- Future Funding issues

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Particle and Nuclear Astrophysics (PNA) Program

PHY – PNA
Process and Advice

We respond to proposals

- Different programs:
  - Career – July deadline
  - PNA – Sept target date
  - MRI – Jan deadline (internal University competition)
- Merit Reviews (email)
- Site Visits/Cost, Schedule, & Technical Reviews (for large requests)
- PNA Panel (gives advice, 14-15 experts, usually in early January)
- HEPAP and its sub-panels (PASAG, DMSAG, NUSAG,…) give advice
- Others (ASTRO2010, …) All of above plus **$$$** levels:
- Programmatic decisions following above, sometimes conflicting advice
- All PNA program recommendations (both awards and declinations) have to be justified and then are reviewed by the Division Director

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Discussions with other Agencies

- We discuss programs with DOE HEP & NP
- We discuss projects with other International Agencies
- Respect confidentiality – get PI's permission
- International Finance Boards
- OECD-GSF-Astrophysics Working Group
- Bi-National Discussions (INFN, IN2P3)
- Attend Lab Scientific Committee meetings (PACs)

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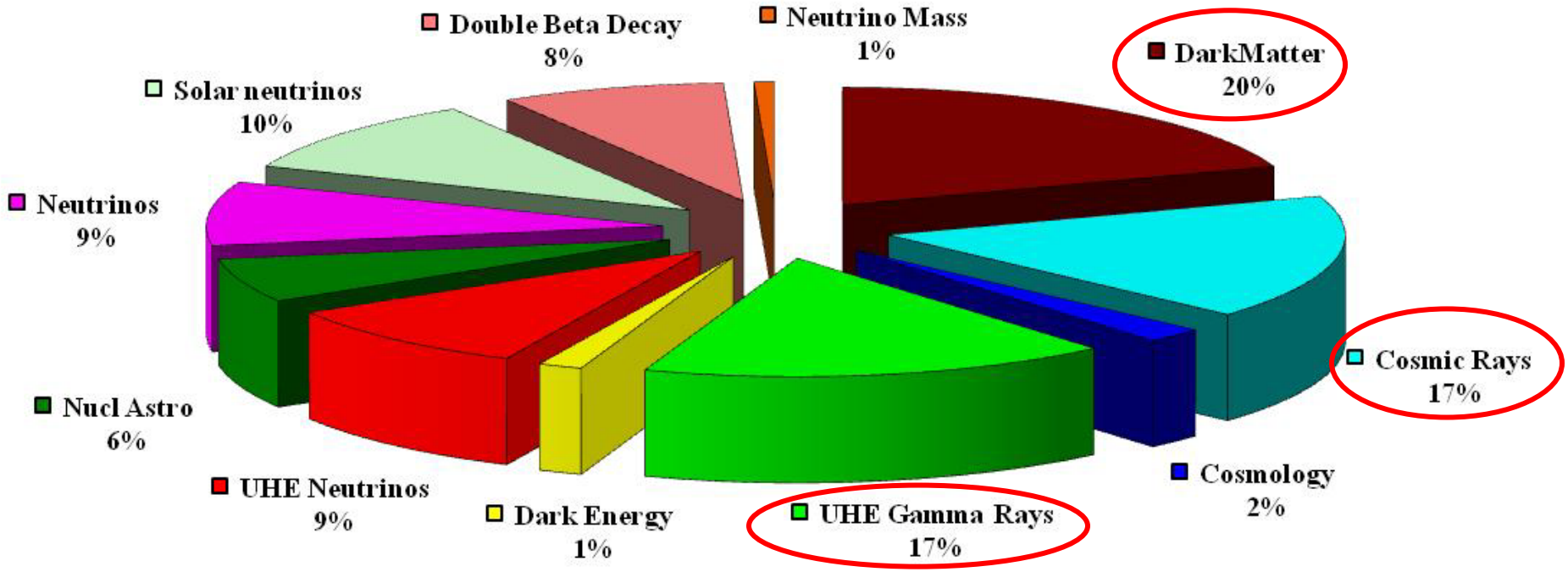
PNA Funding FY10 by topic



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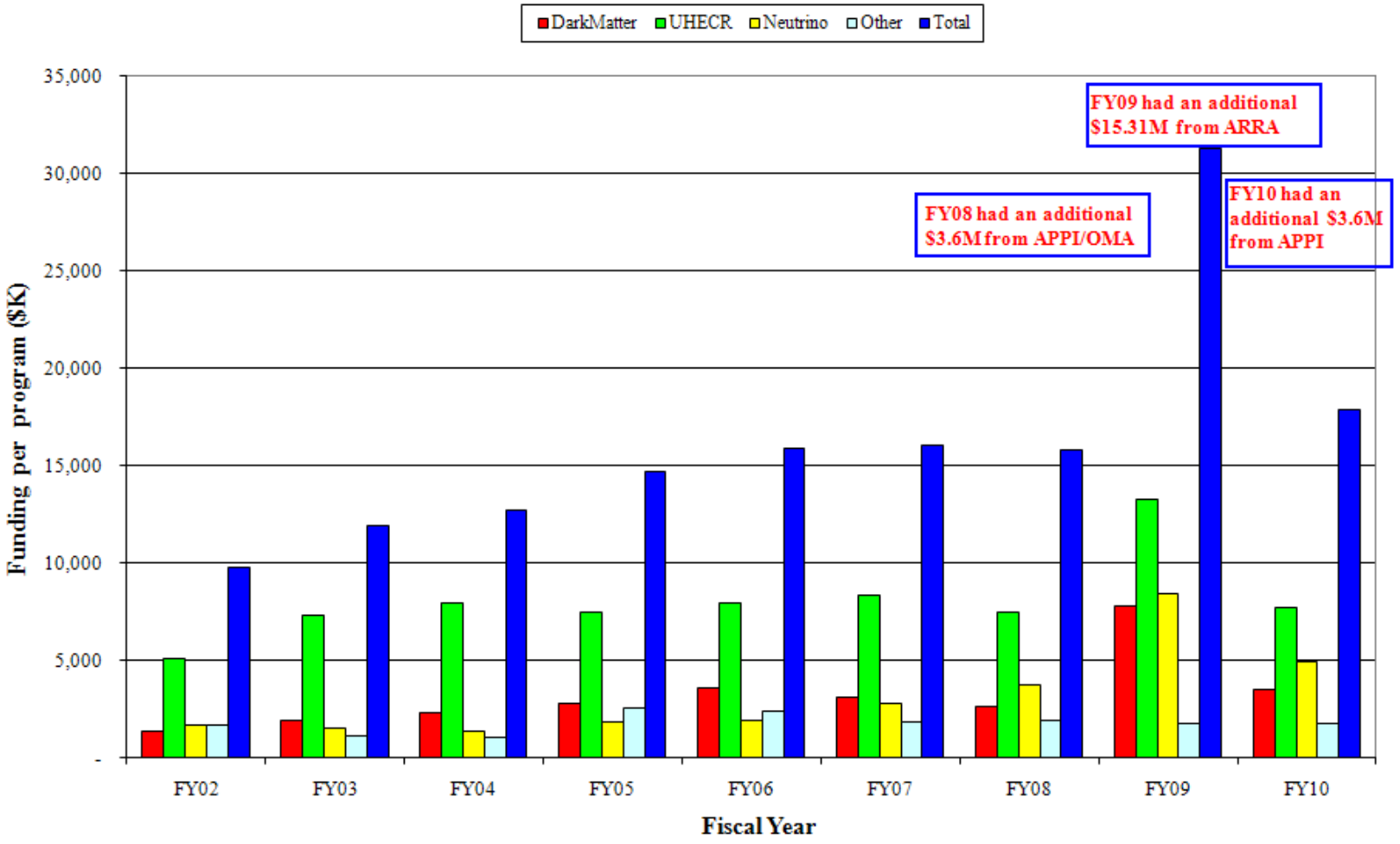
PNA Funding FY02-FY10



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Particle and Nuclear Astrophysics (PNA) Program

Construction and R&D Funding levels ($M)

FY	Undrground R&D	PHY	MPS	MRI PHY	MRI OPP	Sum		PNA program
07	3.11					3.11		2.20
08	4.96	2.00	1.90	0.61		9.47		1.89
09	4.00	2.00		2.22	2.80	11.02		2.37
10	4.50	2.18		1.63		8.31		1.49
11	??	1.90+??		??		1.90+??		??

- PHY: Double Chooz/CDMS/CUORE/HAWC
- MPS (OMA): XENON/LUX/CDMS
- MRI is Major Research Instrumentation:

  MJD electroform/ATTA(XENON)/VERITAS(Upgde)/HAWC/ARIANNA

Construction Funds only

NSF Particle and Nuclear Astrophysics (PNA) Program

Personnel supported by PNA

	FY2007	FY2008	FY2009	FY2010
Number of awards (including CGIs)	**69**	**65**	**88**	**98**
Number of Supplements	**15**	**8**	**16**	**12**
Number of Conferences and Workshops	**4**	**2**	**9**	**6**
Total number of groups/institutions *[1]	**39**	**41**	**57**	**62**
Total number of PIs *[2]	**74**	**74.5**	**101.2**	**139.2**
Total number of Faculty *[3]	**41.2**	**42.5**	**54.9**	**65.1**
Total number of Research Scientists (FTE) *[4]	**6.9**	**11.3**	**9.8**	**8.1**
Total number of Postdocs supported (FTE) *[4]	**40.5**	**38.7**	**48.2**	**52.3**
Total number of Graduate students supported (heads)	**79.5**	**80**	**104**	**118**
Total number of undergraduate students supported (heads)	**63**	**55**	**87**	**98**
Total number of "Other Professionals" from line B2 (FTE) *[4]	**12.6**	**15.9**	**21.9**	**23.3**
<#postdocs/Faculty heads>	**0.55**	**0.52**	**0.48**	**0.38**
<#Other/Faculty heads>	**0.17**	**0.21**	**0.22**	**0.17**
<#Graduate students/Faculty heads>	**1.07**	**1.07**	**1.03**	**0.85**
<#Undergraduate students/Faculty heads>	**0.85**	**0.74**	**0.86**	**0.70**
<$/Faculty heads>	**$180,270**	**$171,865**	**$177,895**	**$143,576**
<$/Faculty FTE>	**$324,179**	**$301,181**	**$327,730**	**$306,805**

#pd and #gs steadily increase, but # per faculty down → more than 50% of the PIs work on more than one project

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Dark Matter
20% -- $3.52M

S-CDMS – at Soudan/SNOLab? Co-fund constr/Ops + 6 groups
XENON – 100 at LNGS/1T? Fund Constr/Ops and 3 groups; co-fund
WARP (1 base group, at LNGS)
LUX – Constr/2 groups base support – Co-fund
COUPP 2 groups base support – Co-fund
PICASSO – (1 group at SNOLab)
CoGeNT (1 group base) Co-fund

<u>Directional projects:</u>
DRIFT – Constr/Ops and 2 groups at Boulby Mine
DMTPC – Constr only (at WIPP) Co-fund

(DOE-HEP, INFN, UK, Germany, Poland)

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Particle and Nuclear Astrophysics (PNA) Program

UHE phenomena Cosmic Rays 17% -- $3.05M

S. AUGER – Ops and base support (10 gps)

(DOE-HEP and 17 more countries)

TA – Constr/Ops/base support (1 group)

(Japan, Korea)

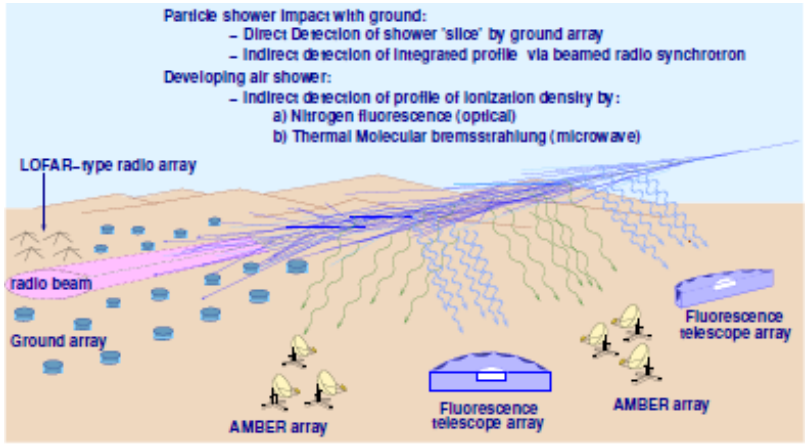
Bistatic radio detection R&D

The collaboration has successfully commissioned a 2 kW bistatic radar transmitter station, operating under station license WF2XHR in Delta, Utah. The receiver station is under construction, and they have begun characterizing the transmitter output (at 54.1 MHz). (Scattering from ionization)

AMBER (Airshower Microwave Bremsstrahlung Experimental Radiometer)

• The indirect observation of secondary emission from the residual tenuous gas of excited particles and plasma left when the shower of particles transits the atmosphere is currently applied only to optical fluorescence of molecular nitrogen.

•AMBER array at AUGER is studying the feasibility of observing UHE cosmic rays via microwave molecular bremsstrahlung radiation (DOE-HEP)



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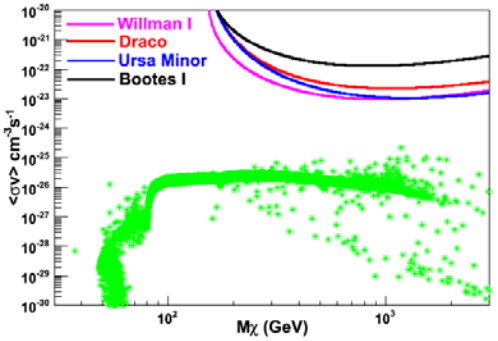
UHE phenomena Gamma Rays 17% -- $2.97M

VERITAS – Upgrade/Ops/base support (10 gps)

- Discoveries of TeV sources of γ-rays
- DM limits from Dwarf Spheroidal Galaxies



(DOE-HEP, Canada, Ireland, Smithsonian)

HAWC – Constr/base support (9 gps)

- 300 large water Cherenkov tanks
- Each tank is 7.3m diam, 5m deep
- At high altitude (4100m), at the Sierra Negra
- Under construction

(DOE-HEP and Mexico)

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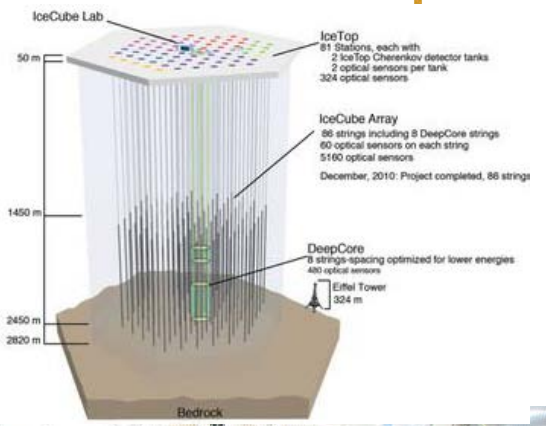
Cosmological Neutrinos
9% -- $1.67M

IceCube (with OPP) Construction was completed at the the South Pole on December 18, 2010 New Zealand time. The main IceCube detector now contains 5,160 optical sensors on 86 strings embedded two kilometers below the NSF's Amundsen-Scott South Pole Station. Includes 6 strings of **Deep Core (low energy).** **(MREFC with Germany, Sweden, Belgium)**

ARIANNA (with OPP) the first prototype for the proposed Antarctic Ross Ice Shelf Antenna Neutrino Array of neutrino detectors was successfully installed. The interface between ice and liquid water below acts as an excellent surface for reflecting radio waves (the detectors monitor for Cherenkov radiation, which has wavelengths within the radio wavelengths). **UHE νs**

ARA (Askaryan Radio Array) R&D (with OPP) To detect the RF emission from neutrino induced showers in RF transparent media. A highly relativistic particle shower is expected to emit broadband radiation adding coherently. The receivers installed in IceCube boreholes were designed to be sensitive in the range of 100 MHz - 1 GHz. **UHE νs**

TAUWER uses the earth-skimming neutrino detection: a two-layer scintillator sampling telescope to detect the upward-moving air showers from hadronic decays. To be located in a mountain bowl with a broad valley between the two ranges.



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Neutrino Properties
18% -- $3.11M

(Non-accelerator physics)

Reactor Neutrinos:

Double Chooz – Constr/Ops/4 groups base support

Daya Bay – 3 groups base support only

Neutrinoless double beta decay searches:

CUORE/Cuoricino (LNGS): 4 groups

Majorana Demonstrator(MJD)

EXO-200 (R&D, 2 base groups)

NEMO-3 (Modane Underground Laboratory; 1 base group)**:**

combines tracking, calorimetry and ToF

Neutrino mass measurements:

Mare-I , II (2 groups) cryogenic microcalorimeters (~2, 0.1-0.2 eV/c^2)

U. Genoa

(DOE-HEP&NP, INFN, France, Germany, Brazil, Japan, Russia, Spain, UK)

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Solar Neutrinos
10% -- $1.83M

Borexino (3 groups)

Geoneutrinos: radioactivity produces all internal heat of Earth

^{8}B and ^{7}Be real time spectra of solar neutrino fluxes

ν-oscillations

(co-fund PNA, and Italian groups)

SNO+: (1 group) Replacing the heavy water in the acrylic vessel with linear alkylbenzene, a liquid scintillator, will yield enhanced sensitivity at lower energies enabling the SNO+ experiment to address several interesting scientific questions. By adding the double beta decay emitter ^{150}Nd to the scintillator, SNO+ has the potential to join the field of neutrinoless double beta decay experiments.

SNEWS: The Supernova Neutrino Early Warning System will provide a high-confidence early warning of a supernova's occurrence to the astronomical community using a coincidence of neutrino signals from these detectors. This alert exploits the prompt neutrino signal's several hour lead time over the shock breakout which produces the first optical signs of the explosion.

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Nuclear Astrophysics
6% -- $1.08M

Origin of the Elements:
ND, JINA-PFC, FSU

The nuclear astrophysics program is centered on the study of low energy nuclear reactions in stellar hydrogen and helium burning. This is of particular importance for the understanding of nucleosynthesis in the first generation of stars after the Big Bang; investigating new sources of neutron production during the He and C burning phases in explosive stellar environments and the source of neutrinos in our sun and other main sequence stars.

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Structure of the Universe share 2% -- $370k

ACT – Constr/Ops (Mostly NSF/AST)

SPT – OPP (Mostly OPP, some AST)

Antarctic Astronomy and Physics
South Pole Telescope Operations funded into 2012

ROTSE-III (Robotic Optical Transient Search Expt, with AST)

Since 1993, the ROTSE project has demonstrated the unique advantages of ground-based, relatively small but agile telescopes for sampling the optical light curves of GRBs within tens of seconds of the initial burst onset, often finding optical radiation overlapping the gamma-ray fluxes. Four identical 0.45-m aperture telescope systems are located in Australia, Texas, Namibia and Turkey. They have discovered about 100 supernovae. Among them are the most luminous supernovae ever identified.

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CMB Polarization
share 2% -- $370k

Polarization of CMB:

QUIET – Ops support and constr in FY06-08 (Mostly NSF/AST)

Results: The QUIET Collaboration has released its first measurement of the Cosmic Microwave Background polarization spectra using the data from its Q-band (43 GHz) receiver. The E-mode spectrum is consistent with the LCDM model, confirming the only previous detection of polarization at the first acoustic peak. The B-mode spectrum is consistent with zero.

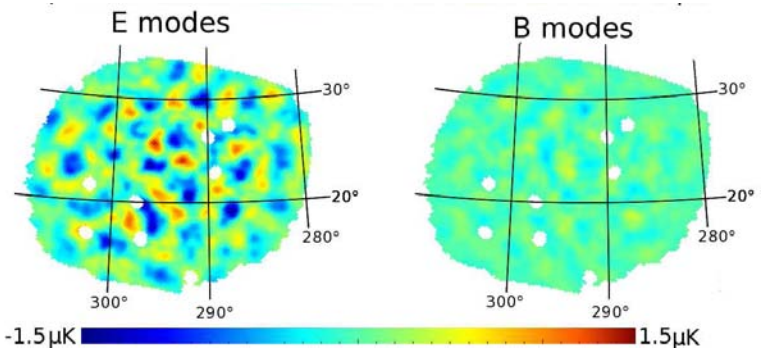

Figure 2: QUIET observing the CMB at the Chajnantor Test Facility in northern Chile.

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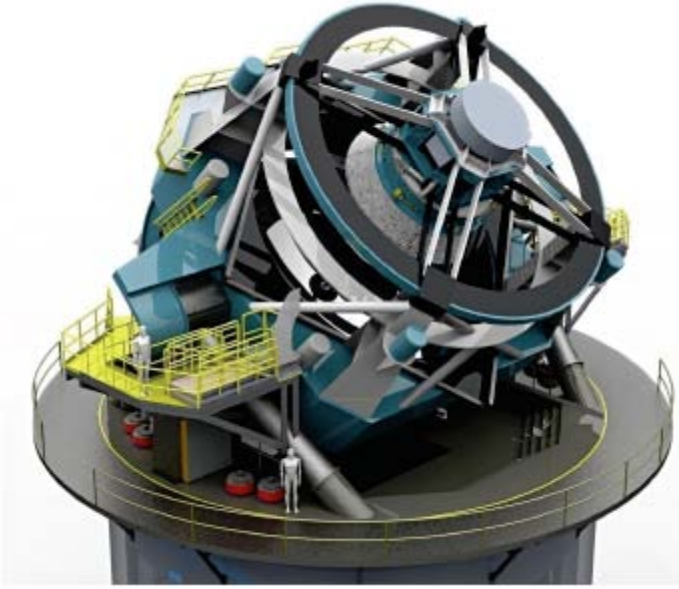
Dark Energy
1% -- $278k

- **PNA: only PI support for 3 particle physics groups on LSST**



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Underground Physics R&D

- Mini-LENS: Neutrinos from the Sun are ideal for studying ν–flavor phenomena and astrophysics. A precision measurement of the neutrino-derived luminosity of the Sun is possible only by the detection of low-energy (<2 MeV) solar neutrinos that contain > 99.9% of the flux. The indium-based Low Energy Solar Neutrino Spectrometer, LENS will uniquely provide a nearly background-free complete spectral image of solar neutrinos using CC-based neutrino detection.
- Ba tagging (liquid and gas) for EXO
- Depleted underground Argon – Princeton
  - Absence ^{39}Ar (<1-2%; ~0.1%); ~1 kg/day -> ~10 kg/day
- NaI in Borexino CTF (DM search)
- Ge Purification – MJD
- DarkSide R&D – at Borexino CTF in LNGS – fund constr plus base for 6 groups

Cosmic Ray Physics R&D

- ARIANNA (Radio reflection in Antarctic – HE Neutrino)
- AMBER (Microwave in S. Auger)
- ARA (RF at IceCube – HE neutrino)
- Bistatic Radio detection in TA

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Status of FY2011 Funding

(from Marv Goldberg, Nov 2010 HEPAP meeting)

For FY 11 and Beyond, Huge Budget Uncertainties

Recently, we (PHY) have been advised to operate on a 5% decrease from FY2010 funding levels – effectively a 15% cut (2/3 committed)

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MPS FY2012 Budget Request

FY 2012 NSF request was **$7,767M ;13%** above the FY2010 Enacted amount

MPS Funding

(Dollars in Millions)

	FY 2010 Omnibus Actual	FY 2010 ARRA Actual	FY 2010 Enacted/ Annualized FY 2011 CR	FY 2012 Request	Change Over FY 2010 Enacted Amount	Change Over FY 2010 Enacted Percent
Division of Astronomical Sciences (AST)	**$246.53**	**-**	**$245.69**	**$249.12**	**$3.43**	**1.4%**
Division of Chemistry (CHE)	233.68	15.70	233.73	258.07	24.34	10.4%
Division of Materials Research (DMR)	302.57	-	302.67	320.79	18.12	6.0%
Division of Mathematical Sciences (DMS)	244.92	-	241.38	260.43	19.05	7.9%
Division of Physics (PHY)	**301.66**	**-**	**290.04**	**300.91**	**10.87**	**3.7%**
Office of Multidisciplinary Activities (OMA)	38.58	-	38.33	43.41	5.08	13.3%
Total, MPS	**$1,367.95**	**$15.70**	**$1,351.84**	**$1,432.73**	**$80.89**	**6.0%**

Totals may not add due to rounding.

AST

PHY

PHY will focus on three major areas for FY 2012: 1) providing continued support for individual investigator awards, especially in those areas that are priorities for the division, including physics of the universe, quantum information science, and the physics-biology interface; 2) ensuring that sufficient funding is available for investigators using the major facilities sponsored by the division; and 3) ensuring sufficient funding to support operations and maintenance of these facilities as they transition to a new era of operations.

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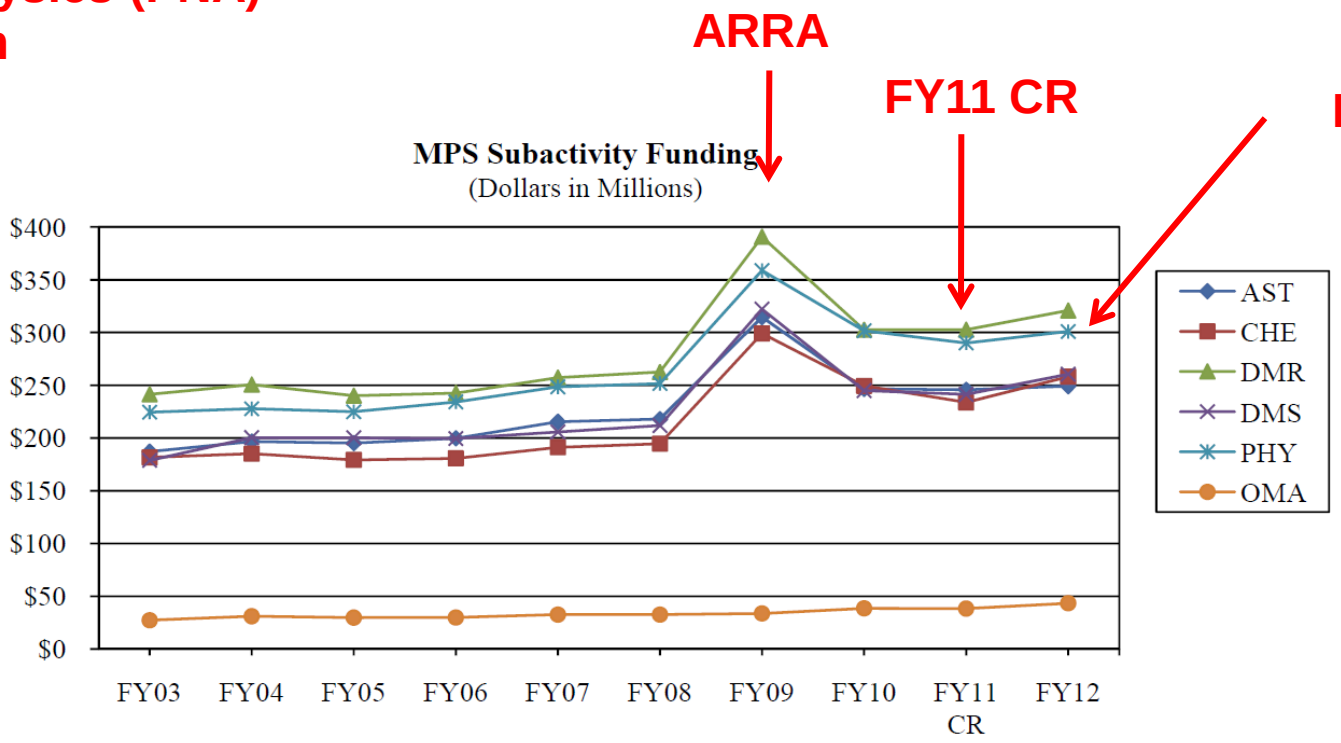
Particle and Nuclear Astrophysics (PNA) Program

MPS FY2012 Budget Request



FY 2012 President's Budget under Terminations, Reductions and Savings

NSF will continue to solicit grant proposals for future particle physics research, including small-scale underground experiments that might be conducted at Homestake (should DOE decide to support the core infrastructure there) or at other existing sites in the United States and around the world.

Comments/ Future

- Oversight – periodic reviews of fabrication projects (often with DOE, both HEP and NP)
- To start new projects, under flat funding, we obviously need to end others
- With DOE/HEP, we are starting to review all major projects to re-evaluate:
  - their science
  - their goals
  - the length of running needed to achieve those goals

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Help wanted!

Program Officer Applications for both PNA and EPP are being sought now!

Typical Recommendation (from Marv Goldberg, Nov 2010 HEPAP meeting):

"You write to ask me for my opinion of X, who has applied for a position in your NSF program.

I cannot recommend him too highly nor say enough good things about him. There is no other with whom I can adequately compare him.

His performance was the sort of work you don't expect to see nowadays and there he has clearly demonstrated his complete capabilities.

The amount of material he knows will surprise you. You will indeed be fortunate if you can get him to work for you.“